Assessment of Occupational Injuries, Health, and Risk Faced by the Workers in the Engineering Workshops: A Survey Based Approach

(Submitted : 27.08.2020 ; Accepted : 04.01.2021)

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Abstract

This study assesses occupational injuries' attributes among workers and the risk associated with the hazards prevailed in engineering workshops. Injury data were collected using a semi-structured questionnaire. Pareto analysis was performed to find the vital few from trivial many. The associated risk levels were measured using a Semi-Quantitative Risk Assessment Matrix. 92% of the worker used to work more than 8 hours per day, and 75% of injuries were found to occur after 8 hours of the working period; this happened due to increased fatigue with the extended working period. 11% of the injuries fell in major and critical severity categories, which caused the workers to be absent for a week to more than a month from their work. Dust, sharp edge and swarf, working without personal protective equipment, and flying object caused more than half of injuries. Wrist and hand/fingers, eye, back and lower back, feet/toe, knee, and arm were the most injured body parts. All the significant hazards identified posed a high level of risk, which makes itself a high-risk workplace.

Keywords: Engineering Workshops; Occupational Injury; Risk Assessment.

1. Introduction

Occupational health and safety at work are deemed to be very significant issues as working people's welfare is largely dependent on them. According to World Health Organization (WHO), the occupational hazard is the risk, harm, or danger that an individual is exposed to at the workplace, whereas occupational diseases result from such exposures to the individual [1]. Due to occupational accidents, workers' safety is imperiled, which adversely affects their livelihoods and their families and those living in the industry's proximity. Every year thousands of people around the world die from industrial accidents [2]. The International Labor Organization (ILO) approximates that due to occupational accidents and work-related diseases, 2.3 million workers die each year. About 337 million occupational accidents and 160 million occupational diseases occur each year worldwide [3]. It is evaluated that due to work-related diseases and injuries, over 4% of the total gross national product (GNP) of all the countries in the world is lost in respect of loss of productivity, compensation, premium of insurance and medical expenses, etc. [4]. The ILO estimation is built upon a fixed compensation system where only a part of work-related cancer is taken into consideration. This is because usually, they are not properly recorded as well as not compensated. In addition, work-related transmission able diseases most of the time remain off the record. Thus if all the factors are taken into account, the financial losses could finally rise even up to 10-15% of the country's GNP [5]. The status quo of occupational safety and health in Bangladesh, a developing country, is especially problematic because workers here are forced to work in unsafe working environments with little consideration of safety issues and inadequate monitoring from government agencies.

Engineering workshops are considered one of the most hazardous industries worldwide because of the number of high-risk activities involved and the ambulatory nature of the workforce where Bangladesh is not an exception. However, workers involved in this sector are often trained on the job and adopt the trainers' shoddy practices and attitude. Occupational health services, especially health education for workers, are often limited or non-existent. Moreover, no notification or registration system for occupational hazards exist in these unorganized labor-intensive industries. Consequently, these groups of workers have little or no knowledge about work-related hazards and risks as well as training on workplace safety.

Thus, numerous research works to assess the work related-hazards in different industries, including the engineering workshops, have been going on for many years. Hossain and Rahman conducted a study on the safety condition of rural engineering workshops in Bangladesh.

The study found that the workers were exposed to excessive noise, working at dangerous elevation, working close to hazardous chemicals in hot places, and working in constricted areas with low air circulation and poor lighting conditions. Dermatitis, asthma, vibration white finger, deafness, shoulder, and neck problems were the most prevalent occupational diseases [6]. Awodele et al. found that only 30% of the respondents received training on hazards and safety measures; 40% of the respondents did not use personal protective devices, and hazard exposure related symptoms were reported by 90% of the respondents amongst the paint factory workers in Nigeria [7]. Taha reported that among laborers working in the 24 workshops in Al-Khobar, 61% of workers did not use personal protective equipment (PPE). Abrasions, lacerations, cut wounds, fall off forklift, sharp flying metal particles, saw-cuts, burns, noise, and hearing-impairment were the major accidents the workers encountered [8]. Philip et al. studied the morbidity among the automobile repair workers in India and found that 50% of them were unaware of the health problems related to their occupational exposures, and thereby the use of personal protection was deficient [9].

Choobineh et al. showed that most of the workers (73.6%) of the Iranian rubber factory had encountered musculoskeletal disorder symptoms during the last twelve months. Manual material handling of heavy loads, lack of rest, awkward working posture, working in a standing position for a long time were the most prominent risk factors the workers experienced [10]. Kabir et al. demonstrated that coughing was the most common respiratory problem among the workers at stone crushing industries in Bangladesh, followed by shortness of breath, chest tightness, and wheezing. These were the consequence of releasing mineralogical materials in the environment like ashes, fumes, and dust [11]. Mitchual et al. conducted a study at a timber company in Ghana and observed that sawmill workers rarely or never wore face shields, goggles, gloves, earplugs, helmet, and nose and mouth mask during wood processing [12]. Islam et al. carried out a cross-sectional study on workers of the tannery industry in Bangladesh to determine occupational health hazards and safety practices among them. They concluded that the vast of the workers were suffering from various occupational diseases caused by various work-related hazards [13]. Ahmed et al., in their study, focused on identifying the most crucial causes of accidents on the construction site in Bangladesh. Lack of expertise/training, lack of safety awareness, and lack of proper attention from authority were found to be the leading causes of accidents [14]. Iqbal et al. illustrated that work-related injury is a severe problem in Bangladesh's cement industry, although most of the injuries (79.1%) result in temporary disability. The study revealed that 82.81% of injuries occurred in finger, hand, arm, leg, head, and eye. 76.56% of total injuries were caused by belt conveyor, welding, weight lifting, and bucket elevators [15].

From the above literature, it is evident that work-related injuries and diseases are highly prevalent among blue-collar workers in the industrial sector, resulting in the loss of a country's gross domestic product (GDP). Due to the involvement of high-risk activities and workers' iterant nature, engineering workshops are deemed one of the most hazardous industries around the world. However, no systematic research work has been done to explore the attributes of occupational hazards and their associated risks in Bangladesh's engineering workshops. Therefore, this article aims to assess the most frequent occupational hazards and their associated risks of injuries faced by workers of engineering workshops. This study focuses on

- ascertaining the attributes of work-related injuries and health issues among the labors working at engineering workshops;
- assessing the risk linked with the identified work-related hazards.

2. Research Methodology

In this study, the data were collected from seventy-five (75) engineering workshops located around the Sylhet, eastern zone of Bangladesh. A pilot survey was conducted, and for the pilot study, participants who had a clear conception of the project area were selected. Based on the primary survey, published literature on the subject of interest, and physicians' expert opinions, a standardized questionnaire comprising of open and closed-ended questions was developed and used. The questionnaires were constructed to collect (a) demographic data of the respondents, (b) injury attribute data, and (c) occupational hazards, the likelihood of occurrence of an incidence, and its severity data required for risk assessment. Prior permission from the owners of the particular concern and verbal approval were taken from the workers. The data collection method included on the spot assessment for physical evaluation of safety environment, semi-structured questionnaire, and participatory approaches. The number of responders has been chosen according to Krejcie and Morgan at 95% confidence interval [16]. The data collected from survey were processed and investigated. In order to determine the vital few that are the most dominant Pareto analysis was frequently performed [17]. Besides, among the three risk assessment methods, semi-quantitative methods arrange hazards into a comparative scale or use a Risk Assessment Matrix RAM) [18-19]. According to Ling et al. (2014), the semi-quantitative risk assessment method is the most preferred technique of stating the risk in the industry [20]. Therefore, the semi-quantitative risk assessment method was used in this study.

In a semi-quantitative risk assessment method, risk can be defined as Risk Value (RV) = Severity (S) x Likelihood (L). The severity of hazards is measured based on their health effects, while the likelihood of hazards is measured based on the occurrence of individual hazards. Table 1 shows the risk assessment matrix used in a semi-quantitative risk assessment method to determine whether the risk value is low, medium, or high.

3. Results and Discussion

This section summarizes the analysis carried out on the data obtained from the survey and the results of this analysis.

3.1 Demographic characteristics of the respondents

Table 2 shows the distribution of demographic variables of the respondents. Of the 384 respondents, all of them were male, which is consistent with the findings of Hossain and Rahman (2014) [6]. More than half of the respondents were of early middle age (53.40%), followed by young adults (43.20%) and late middle age (3.40%). 96.60% of the workers were below 40 years old since the job is physically challenging and difficult to performed by senior personnel. Among the respondents, 20.10% had no formal education, 49.70% had the primary level, and only 30.20% had secondary level education. 90.60% of the respondents were full-time workers, and 8.30% were worked in their own engineering workshop. 53.40% of the respondents worked as machine operator, 29.70% as welder, 6.40% as spray painter, 7.60% as maintenance personnel, 1.60% as assistant of the machine operator, and 1.30% as supervisor. 75% of the respondents had between 6 to 20 years of service in this industry. The majority of the respondents worked between 9 to 12 hours (81.30%), whereas 10.90% worked more than 12 hours a day.

3.2 Distribution of injury severity encountered by workers

Figure 1 exhibits the distribution of injury severity encountered from different accidents during work.

Table 2. Demographic characteristics of the respondents

Variables	Category	%
Gender	Male	100
Age group	18-24 years	43.20
	25-40 years	53.40
	Above 40 years	3.40
Education level	No formal education	20.10
	Up to 5th grade	49.70
	6th to 10th grade	30.20
Employment	Fulltime	90.60
	Part-time	1.00
	Self-employed	8.30
Job category	Machine operator	53.40
	Welder	29.70
	Spray painter	6.00
	Maintenance	7.60
	Assistant to operator	1.60
	Supervisor	1.30
Length of service	0.5 to 5 years	17.40
	6 to 10 years	36.50
	11 to 15 years	28.10
	16 to 20 years	10.40
	More than 20 years	7.60
Working time per day	6 to 8 hours	7.80
	9 to 12 hours	81.30
	More than 12 hours	10.90

Table 1. Risk Assessment Matrix (RAM) for semi-quantitative risk assessment

			Likelihood of exposure (L)				
			Unexpected ($1/10^6$)	Rarely ($1/10^3$-$1/10^4$)	Expected ($1/10^2$-$1/10^3$)	Likely ($1/10$-$1/10^2$)	Most Likely (1/10)
			1	2	3	4	5
Severity (S)	None	1	1	2	3	4	5
	Insignificant	2	2	4	6	8	10
	Minor	3	3	6	9	12	15
	Major	4	4	8	12	16	20
	Critical	5	5	10	15	20	25

Low Risk Level (RV = 1-5); Medium Risk Level (RV = 6-10); High Risk Level (RV = 11-25)

Labors working at engineering workshops confronted accidents at workplaces, which results in injury, and its severity varies from insignificant to critical. Among the respondents, 28% of workers suffered insignificant severity from accidents, requiring a small duration of a break, usually several hours, from work for recovery. 61% of workers suffered minor severity, which required first aid treatment or bed rest at home, usually several days, for recovery. 9% of workers suffered major severity, which required specialized medical treatment or hospitalization for recovery, and 2% of workers suffered critical severity, which resulted in partial/permanent disability and might take several months under medical treatment or hospitalization for recovery.

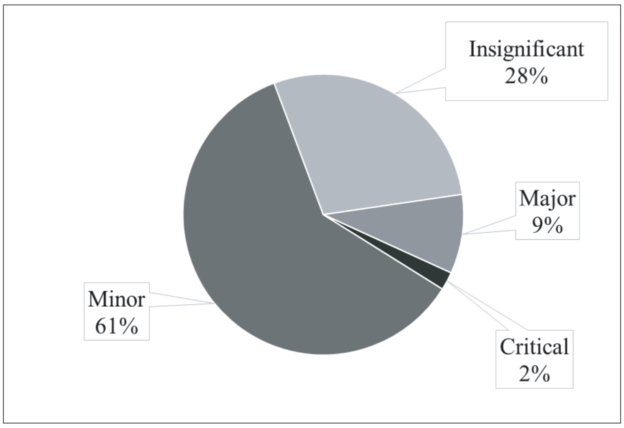

Figure 1. Distribution of injury severity

89% of the total injuries were minor and insignificant, whereas the rest 11% of injuries were critical and major and were responsible for both man and production hour lost.

3.3 Distribution of consequences of the accidents

Figure 2 shows that due to accidents, 33% of the injured workers remained absent from work for two hours to a day, 26% for a day to a week, 26% for a week to a month, and rest 15% were absent for more than a month. From the figure, it is evident that 85% of injured workers remained absent from work for two hours to a month since the significant percentage of injury severity is found minor and insignificant, as can be seen in figure 1. Rest 15% of injured workers remained absent from work for more than a month as the severity level of their injury was major and critical.

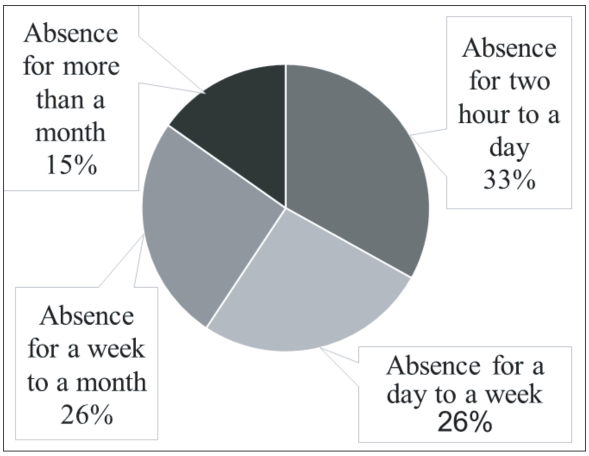

Figure 2. Consequence of the accidents

3.4 Distribution of injuries by time of occurrence

Figure 3 shows the distribution of injuries and the time of occurrence of the accidents. Of 384 responses, 0.50% injuries occurred in between 8:00-10:00 hour, 5.50% injuries occurred in between 10:00-12:00 hour, 18.80% injuries occurred in between 12:00-14:00 hour, 19% injuries occurred in between 14:00-16:00 hour, 20.30% injuries occurred in between 16:00-18:00 hour and rest 35.90% injuries occurred after 18:00 hour in working days. It can be seen that occurrences of injuries increase with working hours; the fewest (0.50%) injuries occurred in the morning period (08:00-10:00 hour) when the worker starts to work and most (35.90%) injuries occurred after 18:00 hours. It is evident from table 2 and figure 3 that 92.20% of the workers worked more than 8 hours a day, and 75.20% of injuries took place after 14:00 hour, which is after 8 hours working duration. This is due to workers' fatigue that increases with time in this highly laborious and monotonous nature of engineering workshops' jobs.

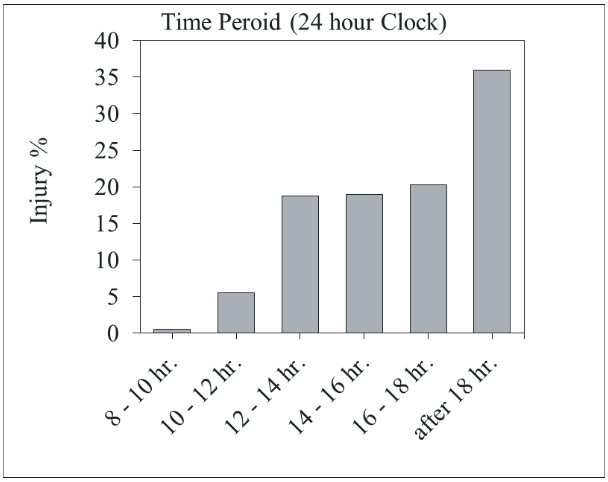

Figure 3. Distribution of injuries by time of occurrences

3.5 Distribution of injured workers by body parts

Figure 4 shows that wrist and hand/fingers (22.87%) were the most injured body parts followed by eye (18.91%), back and lower back (13.52%), feet/toe (12.02%), knee (7.67%), and arm (6.82%); which cumulatively constitute 81.81% of total injuries. The rest 19.19% of the injuries occurred in other parts of the body. However, most of the injuries are avoidable by using Personal Protective Equipment (PPE) during working.

3.6 Distribution of different occupational injuries faced by workers

Table 3 shows that lacerations/irregular tear of skin, eye irritation and red-eye, contusion/bruise, back and lower back pain, abrasions, headache, sharp and deep cuts or indent, crushed hand/fingers/toes, cough, burn, restriction of joint movement, skin irritation and dermatitis, and difficulties in breathing constituted 80.61% of the total occupational injuries faced by workers. Nose irritation, vibration white fingers, ear irritation, throat irritation, visual fatigue/eye strain, difficulties in hearing, amputations of fingers and hand, infected wounds, electrocution, bone fracture and dislocations, and skull fracture constituted the remaining 19.39% of the injuries. Laceration and the deep cut were due to sharp objects. Dust and fumes were responsible for eye irritation, red-eye, and headache. Contusion/bruise was caused due to struck by moving machinery and flying objects. These injuries can be reduced significantly by creating awareness among the workers through training programs and supplying them with proper PPE.

3.7 Distribution of agents of injuries and ill-health

Table 4 shows that dust, sharp edge and swarf, working without PPE, flying object, stressful and awkward posture, highly repetitive actions, aerosol, mist and fume from fluid, direct contact with cutting tools, excessive noise, and being struck by moving machinery constituted 83.56% of the total agents of injuries and ill-health

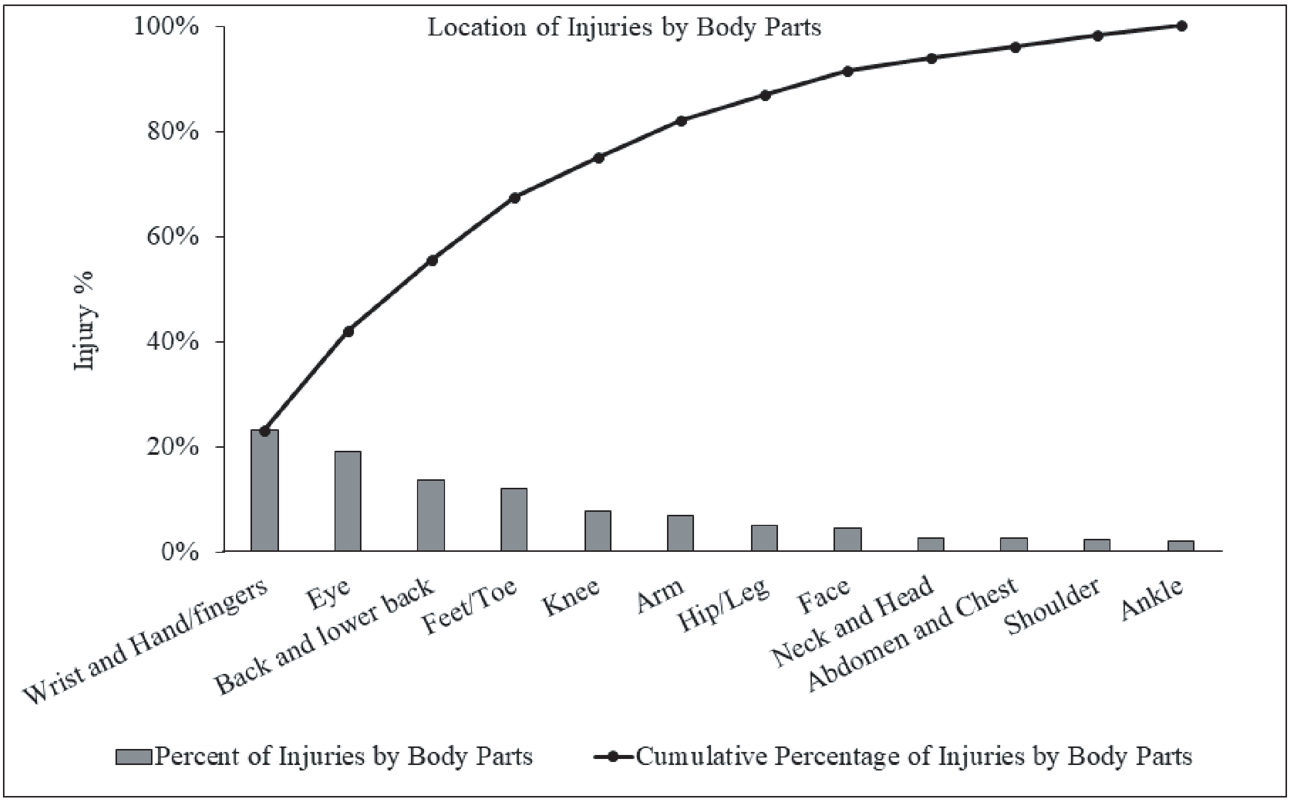

Figure 4. Distribution of injuries by body parts

Table 3. Frequency distribution of different occupational injuries faced by workers

Occupational Health and Injuries	Frequency	Percentage	Cumulative Percentage
Lacerations/ irregular tear of skin	332	9.28	9.28
Eye irritation and red eye	269	7.52	16.79
Contusion/bruise	265	7.40	24.20
Back and low back pain	243	6.79	30.99
Abrasions	240	6.71	37.69
Headache	234	6.54	44.23
Sharp and deep cuts or indent	229	6.40	50.63
Crushed hand/ fingers/toes	227	6.34	56.97
Cough	205	5.73	62.70
Burn	192	5.36	68.06
Restriction of joint movement	176	4.92	72.98
Skin irritation and Dermatitis	138	3.86	76.84
Difficulties in breathing	135	3.77	**80.61**
Nose irritation	124	3.46	84.07
Vibration white fingers	117	3.27	87.34
Ear irritation	103	2.88	90.22
Throat irritation	103	2.88	93.10
Visual fatigue/Eye strain	84	2.35	95.45
Difficulties in hearing	65	1.82	97.26
Amputations of fingers and hand	35	0.98	98.24
Infected wounds	26	0.73	98.97
Electrocution	18	0.50	99.47
Bone Fracture and dislocations	15	0.42	99.89
Skull Fracture	4	0.11	100.00

Table 4. Frequency distribution of agents of injuries and ill-health

Agents of injuries and ill-health	Frequency	Percentage	Cumulative Percentage
Dust	270	15.69	15.69
Sharp edge and swarf	268	15.57	31.26
Working without PPE	222	12.90	44.16
Flying object	212	12.32	56.48
Stressful and awkward posture	106	6.16	62.64
Highly repetitive actions	84	4.88	67.52
Aerosol, mist and fume from fluid	74	4.30	71.82
Direct contact with cutting tools	72	4.18	76.00
Excessive noise	66	3.83	79.84
Being struck by moving machinery	64	3.72	**83.56**
Contact with wires/electrified equipment	51	2.96	86.52
Vibration: Hand grinding	42	2.44	88.96
Falling object	37	2.15	91.11
Electric short circuit/overload	37	2.15	93.26
Entanglement with rotating/moving parts	18	1.05	94.31
Wrong lifting and handling technique	16	0.93	95.24
Low lighting	15	0.87	96.11
Trapping	15	0.87	96.98
Fallen from height	14	0.81	97.79
Direct contact with cutting fluids	12	0.70	98.49
Being struck by falling object	11	0.64	99.13
Slipping and tripping	9	0.52	99.65
Lifting and handling heavy objects	6	0.35	100

cumulatively. According to the Pareto principle, these 43.47% agents of injuries and ill-health were the vital few agents responsible for 83.56% of the total injuries in engineering workshops. Among those vital few agents, dust, sharp edge and swarf, working without PPE, and flying object was responsible for more than half of injuries. Contact with wires/electrified equipment, vibration, falling object, electric short circuit/overload, entanglement with rotating/moving parts, wrong lifting and handling technique, low lighting, trapping, fallen from a height, direct contact with cutting fluids, being struck by a falling object, slipping and tripping, and lifting and handling heavy objects constituted rest (16.44%) of the agents of injuries and ill-health combined.

3.8 Risk analysis

Risk Value (RV) was calculated by multiplying the likelihood of exposure of an event with corresponding severity. For risk analysis, five definitions were used for categorizing both the severity of injuries and the likelihood of exposure.

Most dominant ten hazardous events were selected through Pareto analysis for risk assessment, as those were responsible for 83.56% of total injuries. The probability of the hazardous events and severity of injury resulting from the events was taken from collected data for assessing risk value. The risk level for the hazardous events was calculated based on comparing obtained RV with RAM values, and the result is summarized in table 5.

Table 5 shows the risk level for the most frequent hazardous event in the engineering workshop and related injuries and ill-health. It has been found that all those hazardous events posed a high-risk level. Among the dominant ten hazards, dust, sharp edge and swarf, working without PPE, flying object, direct contact with cutting tools, and being struck by moving machinery posed the highest RV. Since those ten hazards constituted 83.56% of total injuries and all of them posed a high risk, it can be concluded that the engineering workshop is a high-risk industry where injuries and ill-health are inevitable without appropriate control and safety measures.

Table 5. The risk level of the dominant hazardous event

Hazardous Event	Injury (%)	Related Injuries	Risk			Risk Level
			L	S	L×S	
Dust	15.69	Itching, irritating or damaging skin, cough and inhaling problems, eyes irritating	5	4	20	High
Sharp edge and swarf	15.57	Injury in different body parts	5	4	20	High
Working without PPE	12.90	Injury in different body parts	5	4	20	High
Flying object	12.32	Injury to eyes, breathing complications.	5	4	20	High
Stressful and awkward posture	6.16	Ergonomic injuries that can affect the muscles, nerves, tendons, ligaments, joints, cartilage, and spinal discs	4	4	16	High
Highly repetitive actions	4.88	Fatigue, stress	4	3	12	High
Aerosol, mist and fume	4.30	Difficulties in breathing, headache	4	4	16	High
Direct contact with cutting tools	4.18	Tearing and shearing skin, cut and bleeding, crushed different body part	4	5	20	High
Excessive noise	3.83	Difficulties in hearing, headache	4	3	12	High
Being struck by moving machinery	3.72	Crushed hands/ fingers, laceration, abrasion, bruise	4	5	20	High

4. Conclusion

This study has been conducted to assess the attributes of occupational injuries, health issues, and their associated risks faced by workers of engineering workshops. Due to the laborious nature of the job and long working hours, all of the workers were young males. The injury occurrence was inevitable in this industry due to improper and inadequate safety measures, although most of the injuries were of insignificant and minor severity type. The highest number of injuries occurred after 14:00 hours due to increased fatigue with the more extended working period. Wrist and hand/fingers, eye, back and lower back, feet/toe, knee, and arm were found as the most affected body parts. Most of the body parts injury took place since workers did not use PPE. Most of the workers suffered from lacerations, eye irritation, contusion, back and lower back pain, abrasions, contusion, and deep cut, which were caused by dust, sharp edge, working without PPE, flying object, stressful and awkward posture, highly repetitive actions, contact with cutting tools and struck by moving machinery. All dominant hazardous events possessed a high-risk level, which makes engineering workshops a high-risk industry. However, to reduce the risk level, control measures should be implemented and maintained to keep employees safe and sound both physically and economically.

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